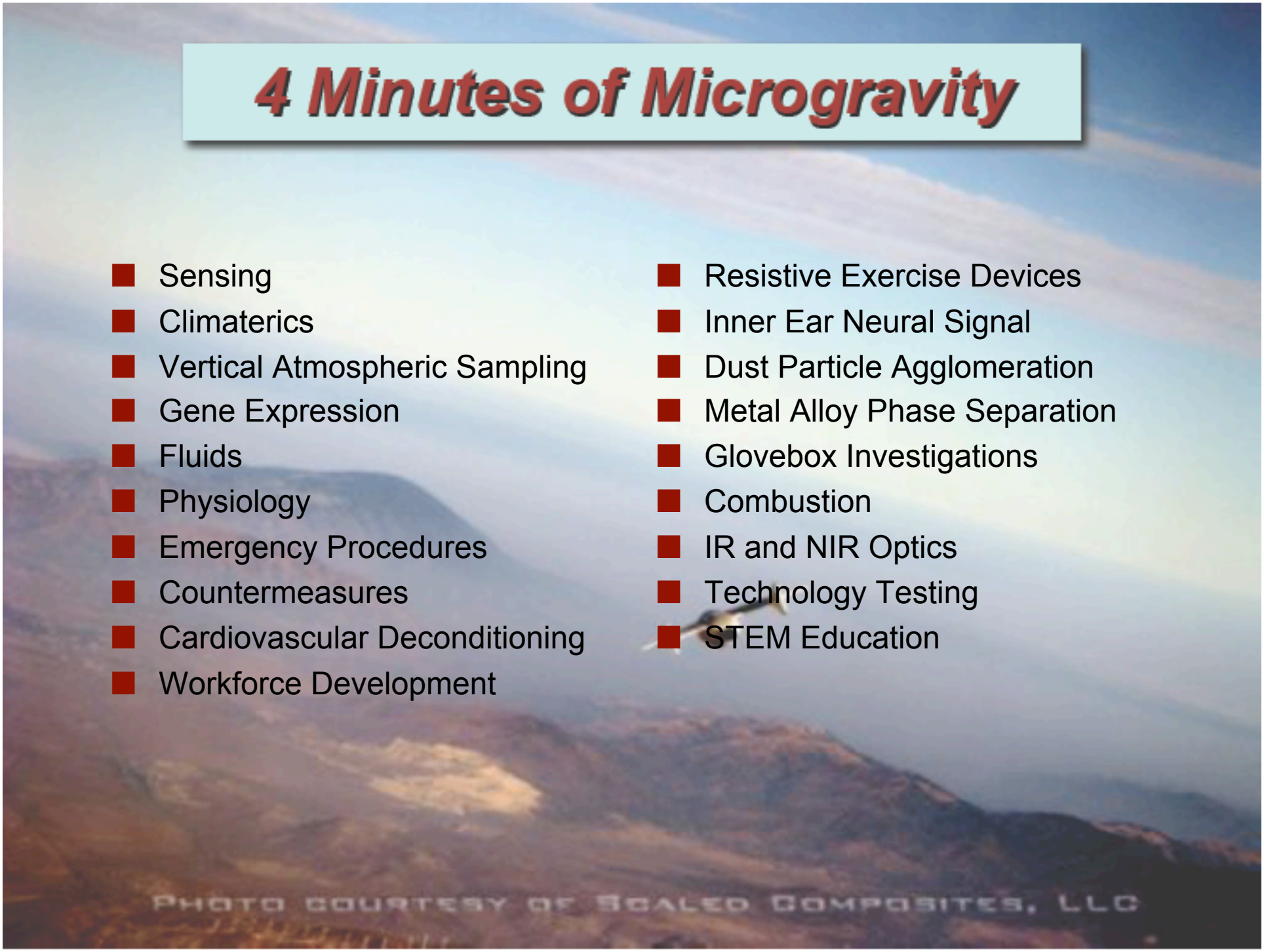
Overview

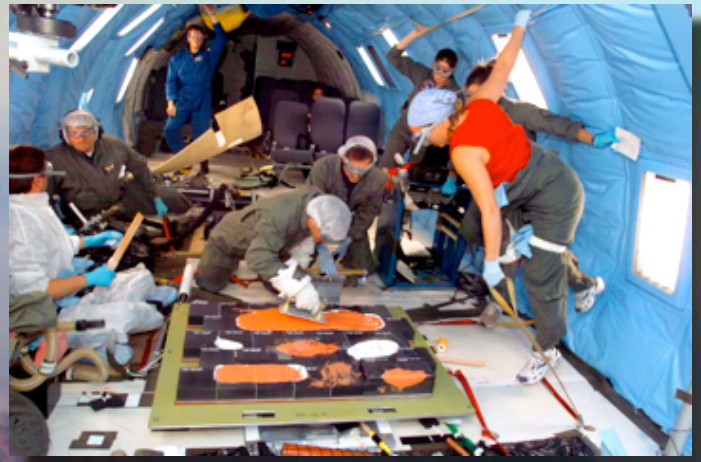
26 May 2009

4 Minutes of Microgravity

- Sensing
- Climaterics
- Vertical Atmospheric Sampling
- Gene Expression
- Fluids
- Physiology
- Emergency Procedures
- Countermeasures
- Cardiovascular Deconditioning
- Workforce Development
- Resistive Exercise Devices
- Inner Ear Neural Signal
- Dust Particle Agglomeration
- Metal Alloy Phase Separation
- Glovebox Investigations
- Combustion
- IR and NIR Optics
- Technology Testing
- STEM Education



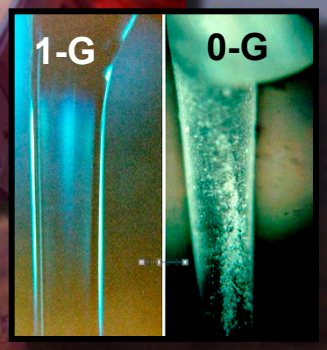
4 Minutes of Microgravity

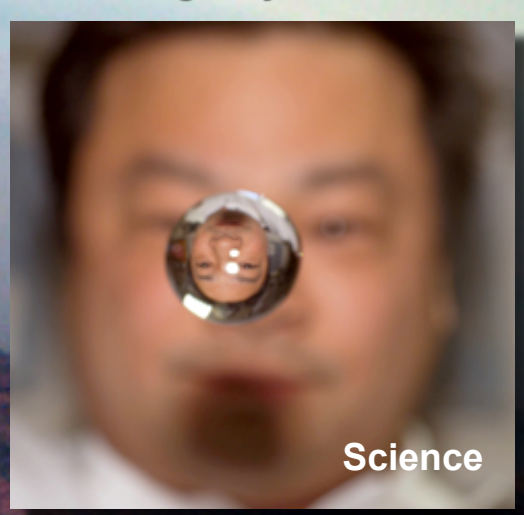


Testing

Emergency Procedures

Technology Development





Science

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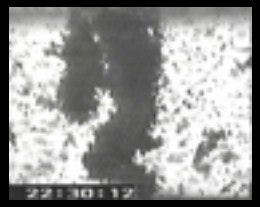
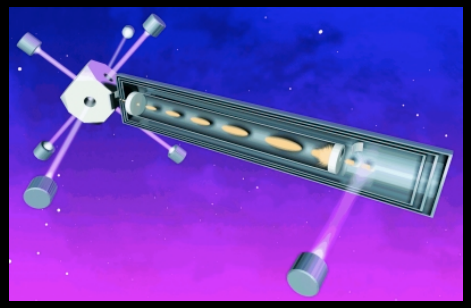
Research Opportunities*

- Earth System Science
- Human Physiology
- Biotech
- Fundamental Physics
- Helioscience
- Astrobiology
- Materials Science
- Observational Science
- Technology Demonstrations
- Accretion, gene expression, enzyme activity, whole organism response to µg, atmospheric vertical sampling, fluid mechanics, small body observations, muscle cell culture matrixing (MCCM), personal resistive training devices, alloy multiphase separation, particle agglomeration, basic physics, student programs…





* Some of the areas suggested by the science community through formal and informal interaction, including RFI's, workshops, invited talks, meetings and conversations.

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Research Opportunities

- Earth System Science
  - Direct atmospheric sampling at high altitudes on regular, responsive, frequent, and global basis

- Fundamental Physics
  - Particle agglomeration
  - Fluid dynamics
- Helioscience
  - Observe solar storms

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Research Opportunities

- Biotech
  - Interest from medical and other commercial bioproduct development entities
  - First opportunity to document genomic precursors that initiate the unique biology seen in microgravity

- Human Physiology
  - Gather human physiological response data to µg and transitions from various g loads during ascent and descent
  - Determine effects on a broader (and predictably less fit) talent pool
  - Study effect of radiation on human physiology
  - Study pulmonary response to lunar dust

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Research Opportunities

- Astrobiology
  - Evidence exists that both microbes and DNA survive at the edges of space
  - Potentially relevant to research on climate change, origin of life, and search for extraterrestrial life
- Materials science
  - Observe how complex multi-phase systems or multi-metal alloys behave differently in μg
  - Commercial applications
- Observational Science
  - Opportunistic astronomical observation
- Technology Development and Testing

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Features

- Non-astronaut investigators conduct their own hands-on research (passenger cost estimated at $200K for the ride based on advertised figure by Virgin Galactic) as well as autonomous studies (launch cost estimated at $50K-$100K based on advertised estimate by XCOR, SpaceX).
- Access to unique regions of the atmosphere for Earth Sciences and Astrobiology
- Access to nominal 3-4 minutes of microgravity for laboratory sciences especially biosciences and materials sciences
- Ability to test and demonstrate technologies in flight environment can move innovation through the "Valley of Death" (TRL 4-7) and lower the risk for incorporation into new missions.
- Recovery of payload
- Frequent flights allow iteration and learning
- Class D hardware

Human Suborbital Flight Program

Platform Comparisons

	Sounding Rockets	Commercial Suborbital	Parabolic Flights
Cost	$0.5M - $1.2M	$200K	$8K
Time in Microgravity (Continuous)	20 minutes	4 minutes	23 seconds
Quality of Microgravity	High	High	Comparatively Low
Launch Frequency	Once every 6 months	Multiple flights per day possible	Multiple flights per day possible
Maximum g-Loading	20 g	2 – 4 g	2 – 4 g
Human Tended Science	No	Yes	Yes

Comparing commercial suborbital research platforms with two other microgravity research platforms

Human Suborbital Flight Program

Platform Comparisons

PLATFORM	Drop Towers	Sounding Rocket	High Alt. Balloon	KC 135	Suborbital Commercial
T/μg	5-10sec.	20 min.	ø	23 sec.	4 min.
Robotic/ Hands on	Robotic only	Robotic only	Robotic only	Hands-on and robotic	Hands-on and robotic
Mass	455 kg	required	500-1000 kg	option	20-100kg
Volume	1 x 1.6 m	required	900-1000 kg	option	option
Altitude	150 m	50 km-1500 km	45-50 km	35 k ft	325 k ft
Cost	Variable	$.5-1.2M	??	$100k	$50K-$200k
Duration	12 sec.	25min.	20-25 hr.	Hr.	20 min.
g experienced	35-65 g	20 g	1-1.5 g	2-4 g	2-4 g
Payload recovery	option	option	option	Yes	Yes
Frequency/ Opportunity	1/mo.	1/ 6mo.	option	Yes	1/week
Science options	Primarily Preliminary tests	Re-entry technologies/ robust payloads	Atmospheric tests	Ultra short duration μg	Wide variety of options

NASA's Human Suborbital Flight Program

Challenges

- New territory in regulatory and liability policy
  - Determine appropriate regulatory environment
  - Determine appropriate liability environment
  - Determine NASA processes for determining safety approvals when NASA provided people will fly
- Providers are not available now
  - Chicken and egg problem for platforms and payloads
  - Many research areas require accommodation (external mounts, air sampling, optical windows, launch on demand, etc.)
  - Costs are projections only and depend critically on leveraging an unproven commercial market (not unlike ELVs)
- Different NASA users have different "business models" for selecting science investigations

NASA's Human Suborbital Flight Program

Benefits

- Through a user-focused program, NASA-sponsored researchers, engineers, technologists and educators would be able to conduct hands-on activities in near-space for the first time.
- This new environment provides several technical benefits to NASA
  - Reducing the risk for use of new technologies in future missions
  - Exploring novel environments to make new discoveries
  - Access to 3-4 minutes of microgravity for discovery and testing
  - Routine recovery of payload
  - Frequent flights
- Provides new options for career development and public engagement
  - Inspiring new careers in aerospace,
  - Training the workforce of the future,
  - Providing a competitive edge for the new commercial space industry
  - Creating greater excitement in the space program
- Provides a competitive edge for U.S. commercial space industry